Fluorine-19 Magnetic Resonance Imaging of the Lungs using Octafluorocyclobutane

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Inert fluorinated gases are promising novel inhalation agents for pulmonary functional magnetic resonance imaging (MRI)[1]. Numerous studies demonstrated the feasibility of fluorine-19 (^{19}F) MRI of the lungs using perfluoropropane (PFP)[2,3] and sulfur hexafluoride (SF_6)[4] for diagnostics and the various lung disorders investigation. High image signal-to-noise ratio (SNR) achievement is possible by a high number of signal averages allowed by short T_1 relaxation times. Furthermore, ^{19}F has a high natural abundance (~100%), a large gyromagnetic ratio, and is absent naturally in the living organism. These benefits result in the maximization of the ^{19}F MRI signal.

Despite wide utilization of PFP and SF_6 gases in research studies, it is feasible to explore other inert fluorinated gases that can enhance the SNR level of ^{19}F pulmonary MRI. In this study, we explored the performance of octafluorocyclobutane (OFCB) as an inhalation agent for ^{19}F pulmonary MRI in healthy rats[5]. OFCB contains eight chemically equivalent fluorine atoms per one molecule (which is a greater number of equivalent ^{19}F atoms compared to other fluorinated gases) and has a longer spin-spin relaxation time. To evaluate the feasibility of OFCB as a fluorinated gas for ^{19}F lung MRI, we conducted a comparative analysis between OFCB and the previously investigated PFP, with the aim of assessing the SNR of OFCB scans in relation to PFP scans.

In vivo relaxation times of OFCB-O_2 mixture were measured as 17.77±1.5 ms and 3.4 ± 0.4 ms for T_1 and T_2^* respectively. Lung images acquired in axial orientation using 70° Ernst flip angle (FA) condition (TR = T_1) and gradient echo (GRE) pulse sequences. The average was performed over either 11s (single breath-hold) or 185 s (continuous breathing) resulting in SNR of 9.72±2.1 and 14.48±4.51 respectively. The same images acquired using PFP gas demonstrated smaller SNR of 9.72±2.0 for the same single breath-hold protocol and of 12.68±4.09 for continuous breathing. OFCB images acquired using continuous breathing protocol and full longitudinal magnetization recovery condition (FA = 90°, TR = 5T_1) showed the SNR equal to 10.23±0.7, whereas PFP images acquired using the protocol demonstrated lower SNR of 8.81±0.46.

OFCB significantly outperformed PFP in all three different imaging protocols ($p < 0.05$). The observed normalized SNR (normalized for the number of signal averages) advantage of OFCB agreed well with theoretical predictions for single breath-hold protocol and for continuous breathing with 90° excitation FA. The SNR of OFCB was up to 21% higher compared to the PFP scans. A slight deviation from theoretical values was observed in the continuous breathing protocol with 70° Ernst angle, potentially due to a minor mismatch between the OFCB T_1 *in vivo* and the TR value used during the scan. In addition, the absence of respiratory gating could explain this discrepancy. In general, OFCB shows a considerable performance advantage over PFP, resulting in notably superior image quality in OFCB scans.

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